MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2022/2023 (TERM ID 2210)

EMG2016 – ELECTROMAGNETIC THEORY

(RE, TE)

06 FEBRUARY 2023
9.00 a.m – 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 9 pages excluding cover page with 4 questions only.

2. Attempt ALL 4 questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the answer booklet provided.

4. Please tear off and attach your completed Smith Chart in the answer booklet.

QUESTION 1

a) An antenna with an impedance of 40 + j30 Ω is to be matched to a 100 Ω lossless line with a shorted stub. Determine the following:

i) The longer distance between the load and the stub, d

[7 marks]

ii) The stub length, l for part (i)

[5 marks]

iii) The shorter distance between the load and the stub, d

[4 marks]

iv) The stub length, l for part (ii)

[4 marks]

Give both solutions using two different Smith chart

b) A lossless transmission line with Z_O=60 Ω is being operated at 60 MHz. The velocity on the line is $3x10^8$ m/s. If the line is short-circuited at the load, find Z_{in} at a distance 1m from the load

[5 marks]

Hint: $Z_{in} = Z_0 \left[\frac{Z_L \cos(\beta l)+Z_0 \sin(\beta l)}{Z_0 \cos(\beta l)+Z_L \sin(\beta l)}\right]$

Continued...

QUESTION 2

a) Name the fundamental law related to each of the following Maxwell equations:

i) $\underline{\nabla} \cdot \underline{\mathbf{D}} = \rho_v$

ii) $\underline{\nabla} \times \underline{\mathbf{E}} = -\partial \underline{\mathbf{B}}/\partial t$

iii) $\underline{\nabla} \cdot \underline{\mathbf{B}} = 0$

iv) $\underline{\nabla} \times \underline{\mathbf{H}} = \underline{\mathbf{J}} + \partial \underline{\mathbf{D}}/\partial t$

[4 marks]

b) State the three situations that will induce V_{emf}

[9 marks]

c) A conducting circular loop of radius 20 cm lies in the z=0 plane in a magnetic field $\mathbf{B}=\hat{z}10\cos 377t$ mWb/m^2.

i) Calculate the flux, Ψ through the loop

[3marks]

ii) Calculate the induced voltage, V_{emf}

[3marks]

iii) Repeat part (ii) if the loop has a coil of N=8 turns

[2marks]

Hint: Area of circle is πr^2

d) The right hand side of the fourth Maxwell equation in part(a) above is the sum of current density, **J** and displacement current density, $\mathbf{J}_d$. Find the displacement current density, $\mathbf{J}_d$, if given $\mathbf{E}=\hat{y}20\cos(\omega t-50x)$ V/m in free space.

[4 marks]

Hint: $\mathbf{D}=\epsilon\mathbf{E}$

Continued...

QUESTION 3

a) Given an electric field $\mathbf{E}=\hat{y}25\cos(\omega t+\beta x)$ V/m, propagating in a medium with $\varepsilon_r = 9$, $\mu_r = 4$, find the following:

i) **E** in phasor form

[2 marks]

ii) The corresponding magnetic field, **H** in time domain

[5 marks]

iii) **H** in phasor form

[2 marks]

iv) The Poynting vector, $\vec{S}$

[3 marks]

v) The Power Density, S_{av}

[2 marks]

b) An electromagnetic wave propagating in free space is incident normally on a lossless, nonmagnetic dielectric medium of $\varepsilon_r = 3$. find the following:

i) Reflection coefficient

[4 marks]

ii) Transmission coefficient

[2 marks]

c) Explain the term skin-depth. What is the skin-depth of a perfect dielectric and a perfect conductor?

[3+1+1 marks]

Continued...

QUESTION 4

a) A rectangular waveguide has dimensions a=1 cm and b=0.5 cm and is filled with a nonmagnetic medium with relative permittivity $\varepsilon_r = 9$.

i) What are the modes that can be propagated if the operating frequency is at 11 GHz?

[8 marks]

ii) What is the dominant mode? Explain.

[3 marks]

b) A rectangular air-filled resonant cavity will resonate at 12 GHz in TE_{101} mode and at 24 GHz in TE_{110} mode. If given a=2b, find the dimension of the resonant cavity.

[6 marks]

c) Describe the propagation of TEM, TE and TM waves.

[6 marks]

d) Find the propagation mode of the wave below which propagates in an air filled waveguide.

$$E_z = 10 \sin\left(\frac{2\pi}{a}x\right) sin\left(\frac{\pi}{b}y\right) \cos(20\pi \times 10^9 t - 3z)\, V/m$$

[2 marks]

Hint:

$$f_{c,mn} = \frac{1}{2\sqrt{\mu\varepsilon}}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

$$f_{r,mnp} = \frac{1}{2\sqrt{\mu\varepsilon}}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2 + \left(\frac{p}{c}\right)^2}$$

Continued...

Appendix : Physical constants

Constant	Symbol	Value
Speed of light in vacuum	c	$3x10^{8}$ m/s
Permittivity of free space	ϵ_o	$8.8542x10^{-12}$ F/m
Permeability of free space	μ_o	$1.2567x10^{-6}$ N/A^2
Intrinsic impedance of free space	η_o	377Ω

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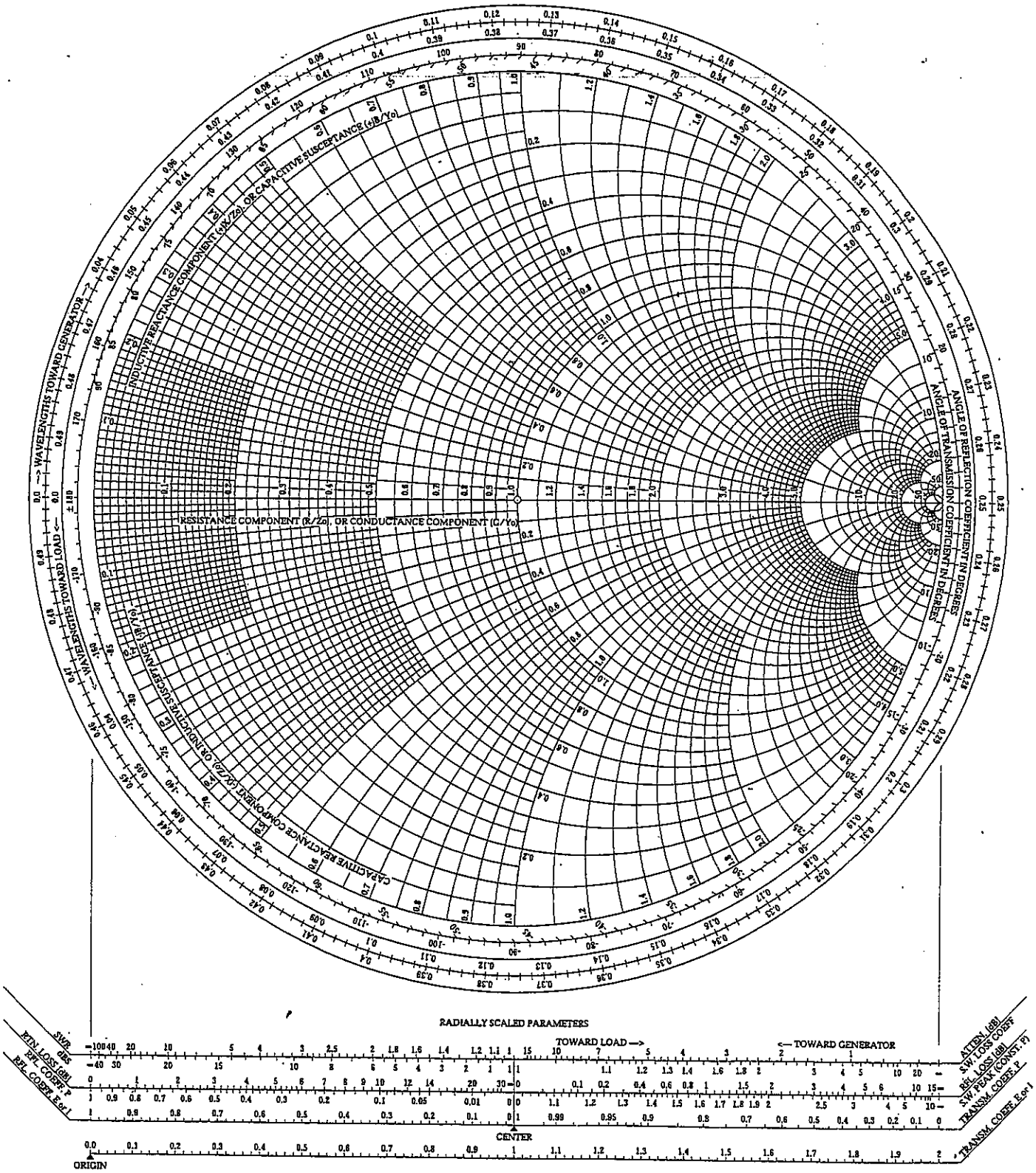
The Complete Smith Chart

Black Magic Design



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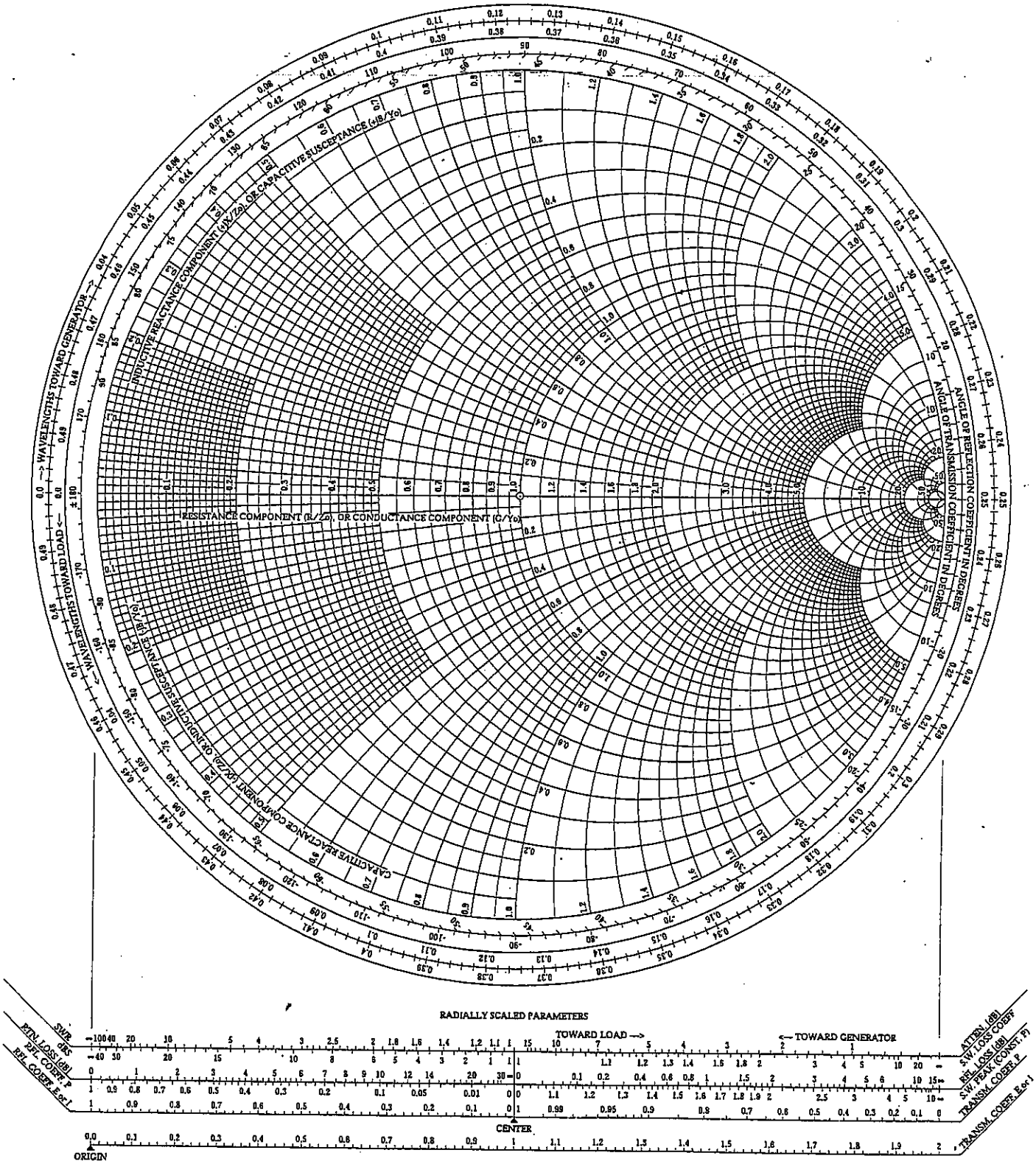

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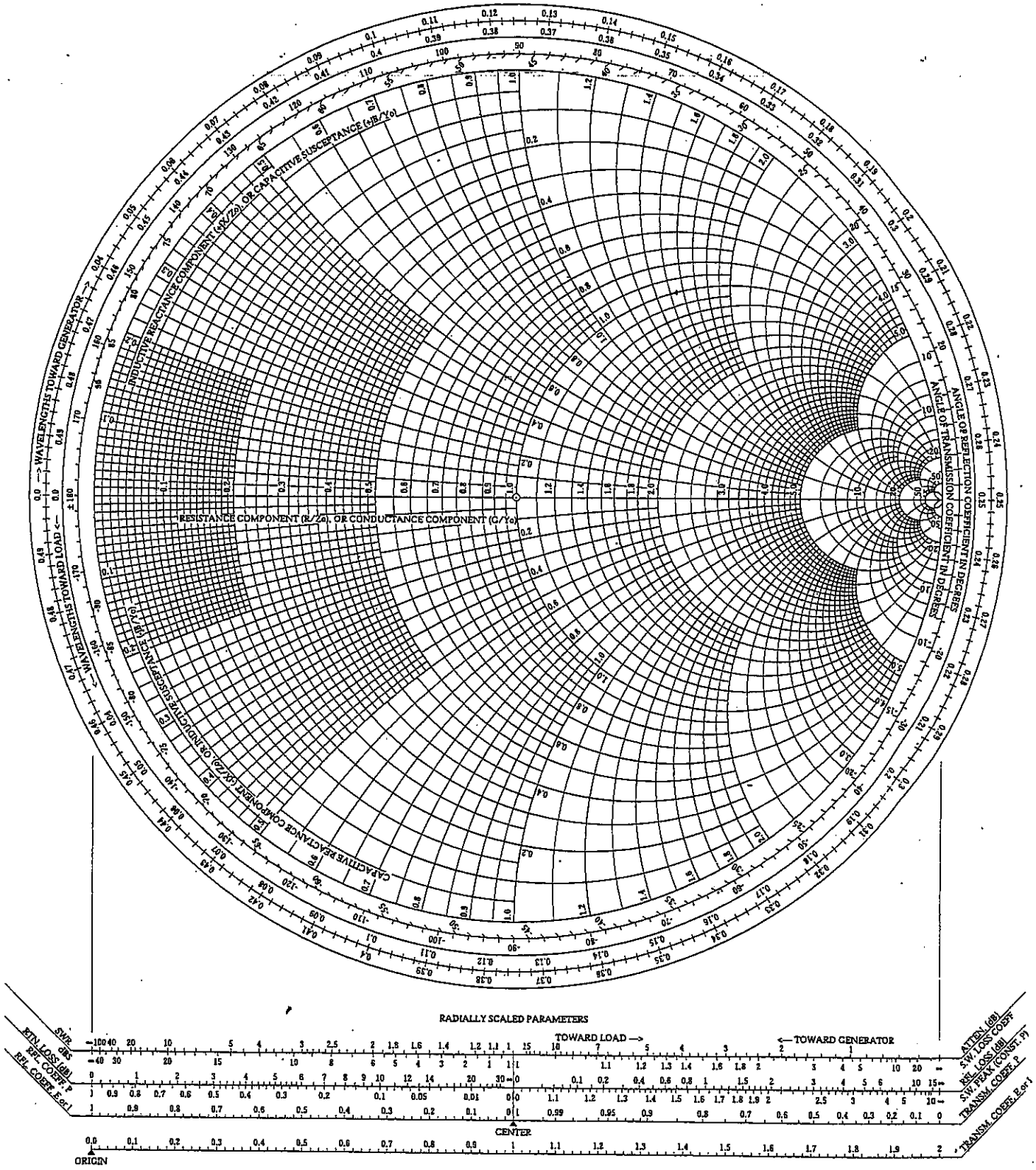

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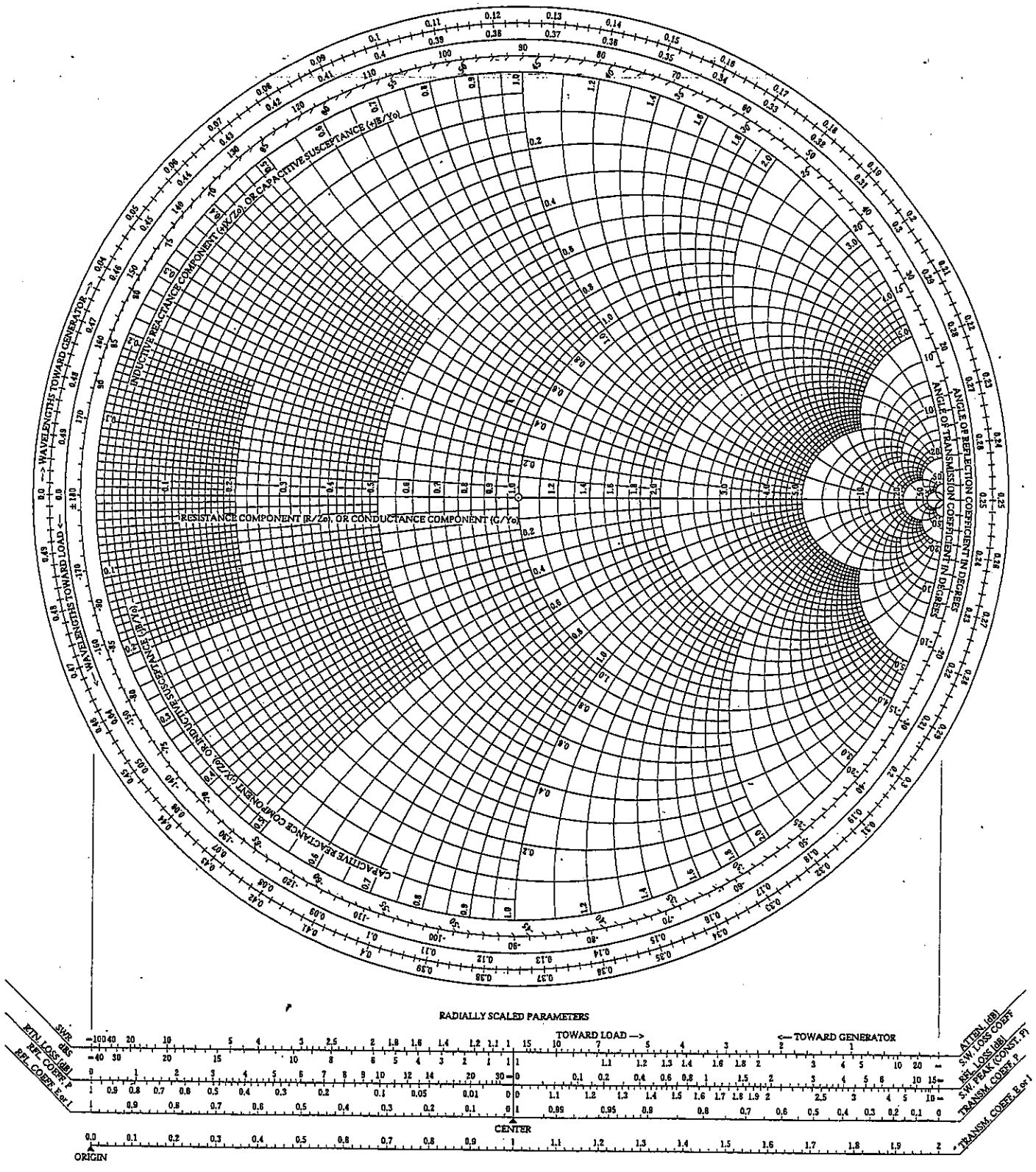

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